Podcast Transcript

The Naked Scientists: Science Radio & Science Podcasts

Remote Monitoring of Plants and Keeping an Eye on Salinity

Mark Tester, University of Adelaide

Mark Tester is professor of plant sciences at the University of Adelaide's Waite Campus where he's building a new facility to root out what makes plants do what they do...

Mark - You know the advances in genomics. Roaring ahead, we can sequence genomes. We can manipulate genomes. We can do extraordinary things with molecular biology. What's starting to fall behind in science, especially in plant science at least, is the ability to measure the effects of those manipulations on the whole plant performance, the growth, and how the plant works when it's fully grown.

So what we need to be able to do is characterize the effects of those manipulations, the growth of the plants in controlled conditions in a high throughput and efficient manner. And that's the driving force behind this new construction we're going to describe.

Chris - Well, set the scene. Is this the world's biggest greenhouse? It looks like it!

Mark - It's not the world's biggest greenhouse but it's the world's biggest greenhouse of this type. What we've got here isn't just a greenhouse. I mean, it's a very impressive greenhouse, but it's a greenhouse that is going to have a large portion of its floor area covered with conveyor belts, and the plants will be moved both dramatically on the conveyors to imaging stations where we'll be using remote sensing technologies to monitor the growth and some aspects of the performance of the plants.

Chris - Why is that helpful? Can't people just walk around and look at plants, anyway? Why do you need that to do it?

Mark - Yeah, of course. We can go around and look at plants, but there's two things: humans are quite slow and expensive. And the other thing is they're notoriously biased in they're looking in their observations and not quantitative. So we're getting objective, quantitative measurements of the way the plants look. Also, with the technologies we're using, we're not just using visible light. We're peering into some of the hidden parts of the plant, what they're doing in the infrared spectrum, how they fluoresce when we irradiate them with ultraviolet radiation.

Chris - So basically, you've got an infrastructure here which means that you can grow plants under very strictly defined conditions. Every plant's going to get the same conditions, and it's going to get assessed in the same way.

Mark - That's exactly right. So when we grow in here, a population of 50,000 plants which we could do for some of the smaller plants, we can have them being automatically measured, non-destructively through time. So, the fact that we're not having to kill the plants and weigh them is another very important feature. And this opens the door for a whole range of genetic studies. It's bringing more genetics into physiology, more physiology into genetics. And if we bring those two fields together, plant science is going to really get a big kick.

Chris - What sorts of questions will you be able to ask them? In what way will you be able to take plant sciences forward with this?

Mark - We can ask questions in two ways. One is to get a gene that's identified and start to ask questions that, what that does to the plant's performance in a quantitative and objective way. The other way, which I think is more powerful in many ways, is what's called a genetic approach, a forward genetic approach, where we can get plants that have got different properties, and start to ask the questions, "What gene is responsible for that difference?" And then we can have a plant that keeps growing well in a salty soil and another plant which dies or doesn't grow as well on the salty soil. What genes are responsible for those? So you're asking the plants the question. Like, "You're tolerant. Why are you tolerant?" And the plants tell you the answer rather than try to sit there and be smart, and say, "Oh, I think it's that gene." And waste your career doing that.

Chris - Which will be bad. Is this the first of its kind in the world, then?

Mark - This is the first of its kind in the world. There's one smaller version in Germany. And there's a couple of slightly different and smaller versions in the private sector, but this is certainly the first to have so many wavelengths, looking at the plants, and certainly in the scale and in the public sectors. So any scientists in the world can come and use this and benefit for their particular scientific questions from this facility.

Chris - What sort of floor area will you have?

Mark - It's four and a half thousand square meters of building, and there's over a kilometre of conveyor belts delivering the plants. So if we have a large plant, like a wheat plant or a sugarcane plant, or a little tree, we can measure those sorts of plants because it's a very tall greenhouse. We're able to measure something like two and half thousand plants at any one time. If we're looking at little plants, we could measure 50,000 plants. And given, you know, in the arabidopsis genome, and a lot of plant genomes, has 25 to 30,000 genes, you can start to look at the effects of knocking at every gene in the genome all at the same time. I think that's quite powerful.

Chris - What about the fact that you're going to have very large numbers of plants all together? How are you going to keep pests at bay and that kind of thing?

Mark - That's a good question. The air in every greenhouse room is completely separate from the air in every other room. And so, we've actually spent $4 million just on the air conditioning for this building. A quarter of the cost of the building is on controlling the airflow. And one of the main reasons for that, besides defining the environment, is to minimize the pests. I think every room has its own air control in and out, isolated. So that reduces the spread of the pests. And we have of course a monitoring and spraying regime which will be in place. We use biological control. And the other thing, because not only there are lots of plants here but they're moving around on conveyors. That's dangerous. So we've got a little spray station. So, as the plants come out from their imaging, they go through a little spray station and get a shower to clean them up.

Chris - And if there's a power cut?

Mark - We're generating our own power, which actually saves a lot of CO2 emission surprisingly. The substrates got good gas, good gas supplies, and so we can pipe in the gas, and generate our own electricity. We generate about 70% of our own electricity on-site.

Chris - Can you send the fumes from the generator through the greenhouse to get the plants to soak up the CO2?

Mark - Yes, you can. We can use the CO2 for controlling CO2 levels in the greenhouse because of course, studying the effect of climate change on plants is very important. So we do have a high CO2 capacity. We use the fumes also for – we extract the energy from the fumes before they leave the building to heat water and heat air as necessary. So, yeah. It's great. It's called a tri-generation system. You get three bangs for one buck.

Chris - What about water? Presumably, you can collect all the water that runs off and put that in tanks, but there's going to be some thirsty plants here.

Mark - Yes. We're able to supply most of our own water supplies from the rain. We're storing a third of a million litres of rainwater. But inevitably, we will need some Maine's water as well, unfortunately. We're recycling all our water. So, 90% of the water is recycled and I'm proud of that. And the main problem isn't the plants. We've got enough water for the plants, pretty much. The main problem is the electricity generating plant that we've got. That uses a lot of water. That uses a couple of million litres and we can't service that. So that's going to have to use Maine's water, unfortunately. But we're still trying to recycle as much of the steam as possible that's lost from there.

Chris - More from Mark Tester later.

Chris - Back to Mark Tester now and how he's helping to solve a major problem that farmers are facing now and in the future, increasing soil salinity. Salt doesn't give plants high blood pressure, but it does lead to an early death.

Mark - The main application from our research is to improve crop production around the world. We all know, we need more food and we need to produce more food in the face of a changing climate. And saline soils are one of the major limitations of crop productivity. Perhaps a third of the world's food is grown using irrigated conditions. And we all know, water is becoming a scarce of resource and the quality of the water is going down. And it's a problem already and perhaps more importantly, it's going to be an increasing problem. It's estimated that a fifth of the world's irrigated lands is significantly affected by salinity and it's getting worst.

Chris - Is this because when we consistently put water out of rivers and things on land and that water may contain a small amount of salt, as that gets consumed by the plants or by evaporation, the salt is left behind so the soil over time, progressively deteriorates?

Mark - Yes, that's exactly right, Chris. And also, if you put water on, you tend to put too much water on and it's seeps back down into the water way from which you pumped the water, and it's going through soil which often has a small number of salt. So you also get a re-circulation of salts building up and building up over time.

Chris - And what does that do to the plants? Why won't they grow on salty soil?

Mark - Yeah, there's a few reasons. But the main one is that the plants try to keep the salt out. In fact, plants are pretty good at keeping most of the salt out. But because there's so much there, beating at the door of the plant's roots, the plants struggle to keep it all out and over time, the salt accumulates up in the shoot, and leads to premature aging of the leaves. And so, the plant which has thrown all that energy into growing all those leaves, loses them. They die before the plants got its money's worth out of those leaves. And so, you get the plant being ground down because of this premature death of its leaves, just due to the simple build-up of the salt.

Chris - So presumably, I mean, one way to tackle this is to, first of all, start to look for plants that do grow quite well on salty or salt-contaminated soils and then ask how they deal with it.

Mark - Yes. There's a couple of ways. You've just described what we would call a forward genetic approach, a genetic approach where we look for natural variation and then understand the molecular basis. You know, what molecules, what genes are different in the plants which have got those differences in terms of salinity and we certainly do that. The other approach is to try to understand the processes, the mechanisms that plants are employing, to try to keep the salt out of the shoots and then see if you can manipulate those processes, using genetic modification.

Chris - And is that what you've done?

Mark - Yes. The reality is you actually do bit of both and to combine the two techniques. And they meet in the middle, which is actually the way we did it. There are genes that encode proteins that transport sodium and one of these genes allows the sodium to move into cells. And what it was these doing, it is actually doing it in the cells that were immediately around the pipes. They're called xylem vessels that move the water from the roots to the shoots. So, the plant tries to keep the sodium out but then some sodium eventually reaches these pipes that are in the centre of the roots, taking the water to the shoot. And it's like a last ditch rescue process by the plants where they say, "Look, that sodium is in those pipes. We can't let it get to the shoot or we're in real trouble." And so, it let's the sodium back into the cells that are immediately surrounding the pipes. And, that slows cells and in some cases, it stops the sodium actually reaching the shoots. And what we did was develop techniques which allowed us to increase the levels of expression of that gene, immediately around those cells that are buried right in the heart of the root to increase this retrieval of sodium out of the water on its way up to the shoot, and that has made the plants so tolerant.

Chris - So how did you do that rather clever trick of making that gene only get turned on in those cells around these xylem vessels because that's the breakthrough step, isn't it really?

Mark - Yes, it is. There's different ways you can do this. One is to try to discover little bits of DNA which will activate genes in specific parts of the plant. So that's one way you can do it a very direct way. In the meantime, we're using a model plant. It's called Arabidopsis. It's a silly little weed, but you can do lots of really nice molecular genetics with it. And what we did was throw into the genome of this little plant, this little weed, a little bit of DNA which allows us to turn on genes. But we threw it on in random in the genome, made thousands of these plants and then looked at the plants to find ones which had the right pattern of expression. So the initial generation of the plants was random and then we looked to find plants which had by fluke, this bit of DNA landing in a part of the genome that would activate that gene only in the inner half of the root.

Chris - Big question though, Mark must be a course, it's one thing to do this in thale cress, the plant sciences fruit fly. But we don't eat that. So what about things that we do eat? Could you put this same genetic combination into rice, into barley, wheat, and so on? The kinds of things we do rely on for food staples.

Mark - Absolutely, Chris. We have done this in rice and the results are looking very promising. We look like we've worked out how to reduce the sodium concentration. Well we have reduced the sodium concentration in the shoots of rice and we're in the process of testing the effect of that on yield. The first experiments did improve yield, but we just want to again be fairly conservative rather than just shooting off the results rapidly. But it's looking very promising. To turn the genes on in wheat and barley, maze, it's actually quite difficult because these molecular genetic tricks that we're able to use on Arabidopsis, we just simply can't do it. We're technically not able to do it in wheat and barley. So what we're doing now is we're having a program to discover the promoters that would help us turn this on, so going back to a very direct but slower way of manipulating an expression in wheat and barley. We actually have transgenic plants in the glasshouse at the moment for wheat and barley and we're limited by bulking up the seed, and we're just at that stage at the moment. So keep your fingers crossed for us and hopefully in the year's time, we'll be able to say if we've done it in the other crops as well.

Chris - What about safety though, because we're already worried about rice because of things like arsenic? Could fiddling around with the way the plant handles certain salts like this have implications for the accumulation in the plant of other things that are not good for us, as well as giving us food, we'll end up eating something we shouldn't?

Mark - Yes, that's a good question and fortunately, we have analytical technologies here in Adelaide to measure a large number of different elements and we have checked that. And it's quite extraordinary. This transporter is very specific for transporting sodium. And it's only one other element that we've measured has an altered – has differences in it's accumulation- that's potassium, which is really not going to affect the nutrition of the plants very much at all. We generally only eat the grain and the grains don't get affected at all, even their sodium.

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Discovering New Viruses

Jane Arthur, Institue of Medical and Veterinary Sciences, Adelaide

Jane - Hi. I'm Jane Arthur and I work at the Institute of Medical and Veterinary Science in Adelaide. And I do studies on what causes gastroenteritis in kids. And so,